

THE OHIO JOURNAL OF SCIENCE

Vol. 70

SEPTEMBER, 1970

No. 5

SHORELINE ALGAE OF WESTERN LAKE ERIE¹

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ABSTRACT

The algae of western Lake Erie have been extensively studied for more than 70 years, but, until the present study by the author, conducted between April and October, 1967, almost nothing was known of the shoreline as a specific algal habitat. A total of 61 taxa were identified from the shorelines. The importance of this habitat is very clear from the results of this study, for, of the 61 taxa found, 39 are new records for western Lake Erie, and one, *Arnoldiella conchophila* Miller, appears to be a new United States record, having been previously reported only from central Russia.

Western Lake Erie has been the site of extensive phycological research since 1898. After some 70 years of algal study, it would be reasonable to assume that all the various habitats would have been thoroughly studied and reported on, but when reports of research were compiled by Dr. Clarence E. Taft for a taxonomic summary, it became apparent that the shoreline had been neglected. Considerable information on the algae of the ponds, marshes, swamps, quarry ponds, open lake, inlets, ditches, and canals has been reported on by individuals and by agencies doing research, and by the algae classes at the Franz Theodore Stone Laboratory, Put-in-Bay, Ohio. Papers containing this information are by Jennings (1900), Pieters (1902), Snow (1902), Stehle (1923), Tiffany and Ahlstrom (1931), Ahlstrom and Tiffany (1934), Tiffany (1934 and 1937), Chandler (1940), Taft (1940 and 1942), Daily (1942 and 1945), Taft (1945 and 1946), Wood (1947), Curl (1951), McMilliam (1951), Verduin (1952), Wright (1955), Normanden and Taft (1959), Taft (1964a and 1964b), and Taft and Kishler (1968). My study of the algae along the shore lines was conducted during the summer of 1967 and has provided data on previously unreported species, as well as an insight into the total algal flora of shoreline habitats.

I wish to extend my appreciation to the following persons for their help during the study: Dr. Clarence E. Taft, Professor of Botany, the Ohio State University; Dr. George J. Schumacher, Professor of Biology, State University of New York at Binghamton; Dr. Francis Drouet of the Philadelphia Academy of Natural Sciences; Dr. Loren Putnam, Director of the Franz Theodore Stone Laboratory; Mr. W. Jack Kishler; Mr. Richard Pecora; and Mr. Richard DeWeese. The work was done while the author held a National Science Foundation Traineeship.

This study, in common with many studies of western Lake Erie, actually considers only that part of the lake where the many islands occur (fig. 97). The shorelines of these islands have diverse habitats, including protected inlets, exposed cliffs, rubble beaches, sand beaches, and temporary pools in rock. Dolomite and limestone rock in the form of smooth or jagged outcrops, concrete, wood, metal, and shoreline vegetation are all substrates on which algae were found.

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The area of the shoreline was arbitrarily defined to be from water one foot in depth to any area on the shore which was made moist by wave action, or where water was confined, such as in rock pools. Most localities were visited at least twice, once early in the year (April to mid-June) and again later in the summer (mid-June to October). One station, the drain from the laboratory director's house, was visited once a week, because it was convenient and supported a substantial growth of algae, due to the organic pollution there.

Algae were collected from the following shoreline localities, which are shown on the accompanying map (fig. 97):

Big Chicken Reef—entire shore.

Catawba Point—from Miller Ferry dock west for 0.1 mile; from Miller Ferry dock east, around Scott Point, and south for 0.1 mile.

East Sister Island—southeast and east shores.

Gibraltar Island—entire shore.

Green Island—northeast corner in cove and rock pools; west end.

Lost Ballast Island—west and south shores.

Middle Bass Island—from east entry to Haunck's Pond, northeast for 0.4 mile toward tip of east point; north shore from 0.15 mile west of Haunck's Pond to 0.2 mile east of Haunck's Pond.

North Bass Island—from south dock west for 0.2 mile; from south dock east to around Honey Point; 0.1 mile of south half of Manila Bay.

Pele Island (Canada)—west side of Fish Point; north shore along Lighthouse Point.

Rattlesnake Island—southwest shore.

South Bass Island—west shore from laboratory director's house, south for 0.1 mile; Peach Point; Hatchery Bay; Terwilliger's Pond; Squaw Harbor; from Parker Ferry dock west along town dock; both sides of the neck on which the monument is located; Buckeye Point, excluding the extreme tip; southeast shore from end of Toledo Avenue for 0.1 mile in both directions; for 0.1 mile in both directions from Lime Kiln dock; for 0.1 mile in both directions from State Park dock.

Starve Island—entire shore; rock pools.

Sugar Island—south shore in area of dock.

Collections were obtained by scraping rock, metal, or concrete with a pocket knife, or by cutting small chunks of wood or breaking off small pieces of vegetation with attached algae. The materials were placed directly into small vials containing Transeau's solution (6 parts water, 3 parts 95% ethanol, and 1 part formalin) thus preserving the material and allowing identification and drawing to be done at a later time.

All taxa are illustrated by one or more figures (figs. 1-96). The figures were drawn from preserved specimens with the aid of a camera lucida. The slides from which identification and drawings were made are in the collection of the author.

SYSTEMATIC CATALOGUE OF SHORELINE ALGAE OF WESTERN LAKE ERIE

This section includes descriptions and figures of all algae, except diatoms, identified in this study from the shoreline of western Lake Erie. The classification follows that used by Prescott (1962). The author finds the newer system of classification of the Cyanophyta by Dr. Francis Drouet (1968 and 1969) worthy of consideration, but feels the older system is more familiar to those working in western Lake Erie.

CHLOROPHYTA

CHLOROPHYCEAE

Volvocales

Haematococcus lacustris (Girod.) Rostaf. (fig. 1)

Smith (1950), p. 110.

Motile vegetative cells biflagellate and enclosed by a wall that lies some distance from the protoplast and is connected to it by strands of cytoplasm. Akinete structure obscured by haematochrome pigment; division of akinetes into 4, 8, or 16 zoospores may be noted; akinete diameter from 8.5 to 19.4 μ .

Generally distributed in island region, in temporary rock pools. Distinguished by the rust-red appearance of the akinetes.

Tetrasporales

Tetraspora gelatinosa (Vauch.) Desvaux (figs. 2, 3)

Prescott (1962), p. 88.

Thallus an attached gelatinous sac, later becoming a globular mass. Cells arranged in two's and four's when thallus is young, becoming irregularly arranged in older thalli. Chloroplast parietal, cup-shaped, with a single pyrenoid. Two long pseudocilia occasionally observed extending from cells to beyond colonial mucilage. Cells 6 to 10 μ in diameter.

Generally distributed in island region from late July through August, attached to submersed rock and to old *Cladophora*.

Ulothricales

Ulothrix tenerrima Kuetzing (figs. 4, 5, 6)

Prescott (1962), p. 96.

Filaments unbranched, cylindrical, slightly or not constricted at the cross walls. Chloroplast a parietal plate extending about two-thirds around the cell circumference and almost the entire length of the cell. Vegetative cells 12 μ in diameter and 10.9 μ long, becoming broader and somewhat shorter during isogamete formation.

Generally distributed in island region, especially in early spring, but continuing in small numbers throughout the summer. Attached to submersed substrates.

Ulothrix variabilis Kuetzing (fig. 7)

Prescott (1962), p. 97.

Filaments unbranched, cylindrical, not constricted at the cross walls. Chloroplast a parietal plate encircling about two-thirds around the cell circumference; one pyrenoid. Cells 6 to 7 μ in diameter, 6 to 15 μ long.

Generally distributed in island region in early spring and late fall, on submersed substrates.

Hormidium subtile (Kuetzing?) Heering (fig. 8)

Pasher (1914), p. 47.

Filaments unbranched, cylindrical. Chloroplast a parietal plate extending one half or less of the cell circumference; one pyrenoid. Cells 6 μ in diameter, 4 to 7 μ long.

Generally distributed in island region, attached to floating logs, old wood docks, or submersed dolomite.

Uronema elongatum Hodgetts (fig. 9)

Prescott (1962), p. 98.

Short, unbranched filaments, epiphytic on larger filamentous algae. Basal cell with a holdfast; apical cell tapering and greatly curved. Chloroplast a parietal plate extending two-thirds around the cell circumference and from one half to almost the length of the cell; two pyrenoids. Cells 7.3 μ in diameter, three times their diameter in length.

Green Island and South Bass Island, occurring on *Cladophora* and on *Hydrodictyon*.

These plants show a much greater recurvature of the apex than do those previously reported by Taft and Kishler (1968) from North Bass Island.

Chaetophorales

Stigeoclonium amoenum Kuetzing (fig. 10)

Islam (1963), p. 106.

Plant a well-developed, upright, branched filament, attached to substrate by rhizoids. Branching mostly opposite; cell size in branches less than that in main axis and ending in blunt points. Main axis consisting of long cylindrical cells 16 to 18 μ in diameter, three to four times longer than broad, and of short quadrate cells, which appear abruptly in a series and give rise to secondary branches.

Big Chicken Reef, North Bass Island, and South Bass Island, on submersed rock. Probably generally distributed in island region.

Stigeoclonium carolinianum Islam (figs. 11, 12, 13)

Islam (1963), p. 77.

Plant a well-developed, upright, branched filament, attached to substrate by rhizoides. Branching mostly alternate, but not infrequently opposite; branch cells smaller than those of the main axis and ending in pointed apical cells. Clusters of globular cells formed on the main axis and on primary branches look like sporangia and are about $9.7\ \mu$ in diameter and $24.5\ \mu$ long. Main axis of cylindrical, somewhat thick-walled cells; cells $14.5\ \mu$ wide, 10 to $36\ \mu$ long, the shorter cells giving rise to secondary branches.

Catawba Point, on submersed substrates.

The diameter of these cells is greater than that reported by Islam (1963), but the globular, sporangia-like cells appear the same. Dr. George J. Schumacher, who first found this alga, concluded, after looking at the material, that, on the basis of the sporangia-like cells, it is *S. carolinianum*. The cell size and wall thickness match those of *S. pachydermum* collected from the same point. This latter species may simply represent a stage in the life history of the former plant.

Stigeoclonium elongatum (Hassall) Kuetzing (fig. 16)

Islam (1963), p. 104.

Plant a well-developed, upright, branched filament. Branching alternate and opposite; branch cells smaller than those of the main axis and ending in sharply pointed to long flagilla-form tips. Cells of main axis somewhat constricted, consisting of long cells 7.3 to $12\ \mu$ in diameter, four to seven times longer than broad, and short quadrate cells, which give rise to secondary branches.

Middle Bass Island, Pelee Island, and Rattlesnake Island, on submersed substrates. Probably generally distributed in island region.

Stigeoclonium lubricum (Dillw.) Kuetzing (figs. 14, 15)

Islam (1963), p. 118.

Plant a well-developed, upright, branched filament. Branching mostly opposite, but occasionally alternate; branch cells little narrower in diameter than those of main axis and ending in a rounded or bluntly pointed tip. Cells of main axis barrel-shaped and thick-walled, $20.5\ \mu$ in diameter, 15.7 to $26.6\ \mu$ long; shorter cells giving rise to secondary branches.

Catawba Point, Pelee Island, and South Bass Island, on submersed substrates. Probably generally distributed in island region.

Stigeoclonium pachydermum Prescott var. *pachydermum* (figs. 17, 18, 19)

Islam (1963), p. 133.

Plant a well-developed, upright, branched filament attached to substrate by rhizoides. Branching irregular, mostly alternate or unilateral and characterized by many short, thorn-like branches growing in many directions and ending in blunt tips. Cells of main axis barrel-shaped and thick-walled (up to $2.5\ \mu$ thick), $14.5\ \mu$ in diameter and 12 to $24\ \mu$ long.

Catawba Point, East Sister Island, and South Bass Island, on submersed substrates. Probably generally distributed in island region.

Stigeoclonium stagnatile (Hazen) Collins (figs. 20, 21)

Islam (1963), p. 89.

Plant a well-developed, upright, branched filament. Branching mostly alternate, but occasionally opposite; ending in a sharp point. Curved secondary and tertiary branches common. Cells of main axis cylindrical, $9.7\ \mu$ in diameter, quadrate to two and one half times longer than broad.

Middle Bass Island and South Bass Island, on substrates washed by waves.

Stigeoclonium subsecundum (Kuetzing) Kuetzing var. *subsecundum* (figs. 22, 23, 24, 25)

Islam (1963), p. 84.

Plant a well-developed, upright filament. Branching alternate and unilateral; branches gradually tapering to pointed tips, or short and thorn-like. Cells of main axis cylindrical or somewhat barrel-shaped, 6 to $9.7\ \mu$ in diameter, 7.5 to $24\ \mu$ long.

Catawba Point, Middle Bass Island, and South Bass Island, on submersed, washed, or splashed substrates. Probably generally distributed in the island region.

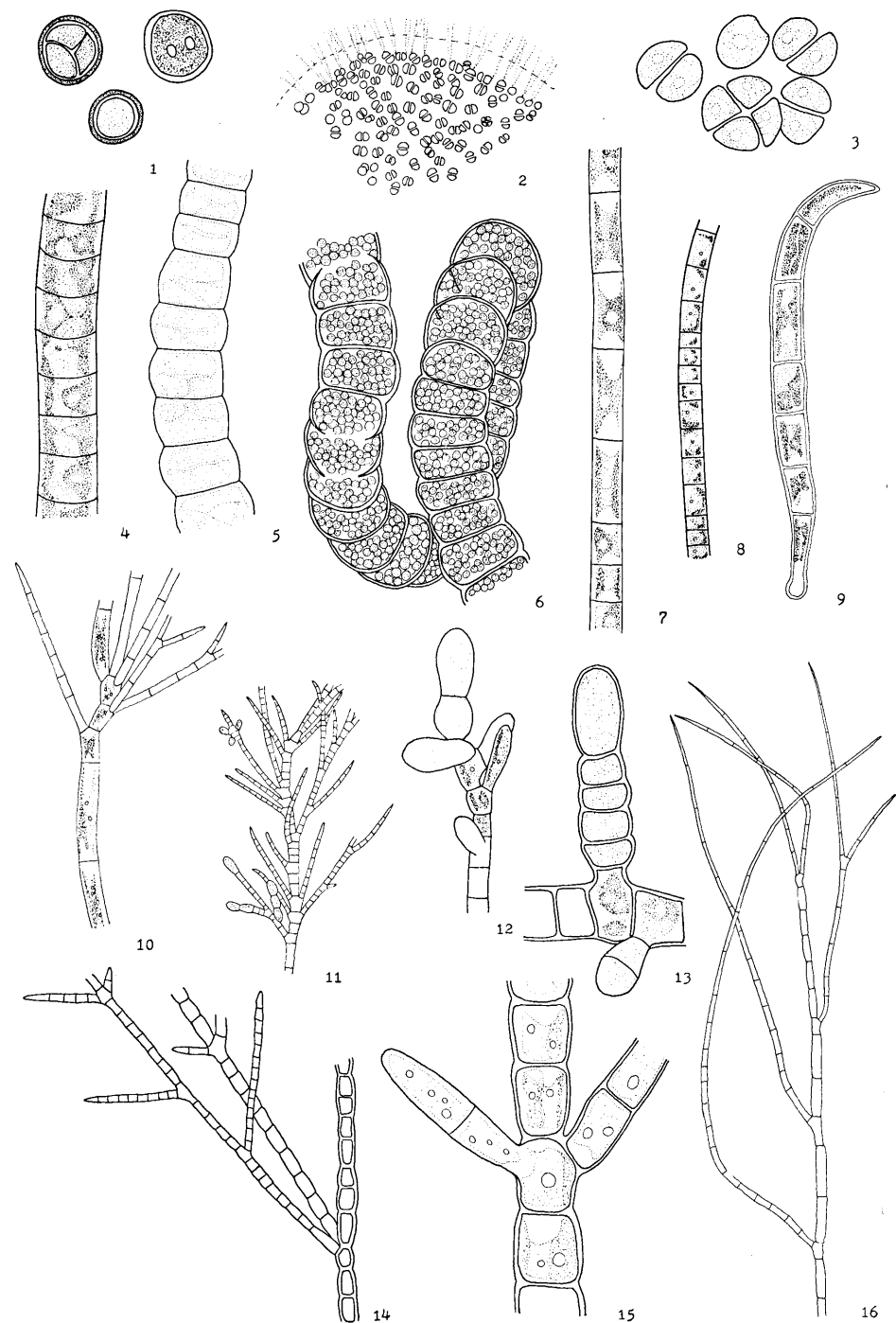
Stigeoclonium tenue (C. A. Agardh) Kuetzing var. *tenue* (fig. 26)

Islam (1963), p. 92.

Plant heterotrichous with well-developed, upright filaments and a flattened, prostrate system. Branching mostly alternate from shorter quadrate cells of the main axis, ending in

EXPLANATION OF FIGURES 1-16

FIGS. 1-16. FIG. 1. *Haematococcus lacustris* (Girod.) Rostaf.: akinetes. FIGS. 2, 3. *Tetraspora gelatinosa* (Vauch.) Desvaux: 2, cell arrangement; 3, cell detail. FIGS. 4, 5, 6. *Ulothrix tenerrima* Kuetzing: 4, vegetative filament; 5, beginning isogamete formation; 6, filament with isogametes. FIG. 7. *Ulothrix variabilis* Kuetzing. FIG. 8. *Hormidium subtile* (Kuetzing?) Heering. FIG. 9. *Uronema elongatum* Hodgetts. FIG. 10. *Stigeoclonium amoenum* Kuetzing. FIGS. 11, 12, 13. *Stigeoclonium carolinianum* Islam: 11, habit; 12 and 13, detail of sporangia-like cells. FIGS. 14, 15. *Stigeoclonium lubricum* (Dillw.) Kuetzing: 14, habit; 15, cell detail. FIG. 16. *Stigeoclonium elongatum* (Hassall) Kuetzing.



sharply pointed tips. Cells of main axis cylindrical, slightly constricted, 10 to 12 μ in diameter, two to five (six) times longer than wide.

Generally distributed in island region during summer, on submersed substrates.

Aphanochaete repens A. Braun (fig. 28)

Prescott (1962), p. 125.

Filaments short, entire length closely adhering to larger filamentous algae. Seta long with unsheathed, bulbous base present on one or more cells of the filament. Chloroplast a parietal plate with one pyrenoid. Cells 4.8 to 6 μ in diameter, 7 to 12 μ long.

Green Island, Middle Bass Island, and South Bass Island, on *Cladophora* filaments. Probably generally distributed in island region.

The filaments have a smaller diameter than that reported by Prescott (1962), but otherwise conform to the description given for this species.

Aphanochaete vermiculoides Wolle (fig. 29)

Prescott (1962), p. 125.

Filaments short, arched, attached to larger filamentous algae only at a few points. Seta with an unsheathed, bulbous base. Cells somewhat inflated, 4.8 to 7 μ in diameter, 4.8 to 11 μ long.

Gibraltar Island and South Bass Island, on *Cladophora* filaments.

Though arched and otherwise conforming to Prescott's description of this species, the material could be *A. repens*. In all cases, it was found on *Cladophora* in areas subject to drying along the shore. Therefore, the arched appearance may occur because of desiccation and the pulling away of *Cladophora* cells from the epiphytic *Aphanochaete*.

Protococcus viridis C. A. Agardh (fig. 27)

Prescott (1962), p. 127.

Spherical unicells or clusters of angular cells of indefinite shape. Cell wall thick; chloroplast a lobed parietal plate with a single pyrenoid. Cells 5 to 13 μ in diameter.

Generally distributed in island region, on substrates washed or splashed by waves.

This alga, most familiar as the green film on moist trees, boards, and rocks in a subaerial habitat, tends to form clusters of great numbers of cells when in aquatic habitats.

Coleochaete orbicularis Pringsheim (fig. 30)

Prescott (1962), p. 129.

Thallus a regular, circular, prostrate disk, one cell in thickness; disk of branching filaments radiating from the center and joined laterally. Sheathed setae present. Chloroplast a parietal plate covering most of the cell wall; one pyrenoid. Cells in the center quadrate, 9.6 μ in diameter. Outside cells 4.8 μ in diameter, 18 μ long.

South Bass Island, on submersed *Vallisneria americana* Michx. in Fishery Bay.

Trentepohlia aurea (L.) Martius (figs. 31, 32)

Prescott (1962), p. 133.

Thallus a rusty brown, velvety expanse of irregularly branched filaments. Cells cylindrical or somewhat expanded, with thickened cell walls. Terminal cell rounded, occasionally with a cap of pectose material. Globose sporangia lateral and terminal, 24 μ in diameter. Filaments tapering somewhat to the tip; cells at base of main axis 16.9 μ in diameter, 24.2 μ long.

Generally distributed in island region, on rock kept moist by wave action.

Cladophorales

Cladophora fracta (Dillw.) Kuetzing (fig. 33)

Prescott (1962), p. 137.

Thallus filamentous, repeatedly alternately branched, the branches often curving, ending in rounded tips. Chloroplast reticulate parietal with many pyrenoids. Cells cylindrical, those of main axis broader than those of branches, 16.8 to 24 μ in diameter, length four to five times the diameter.

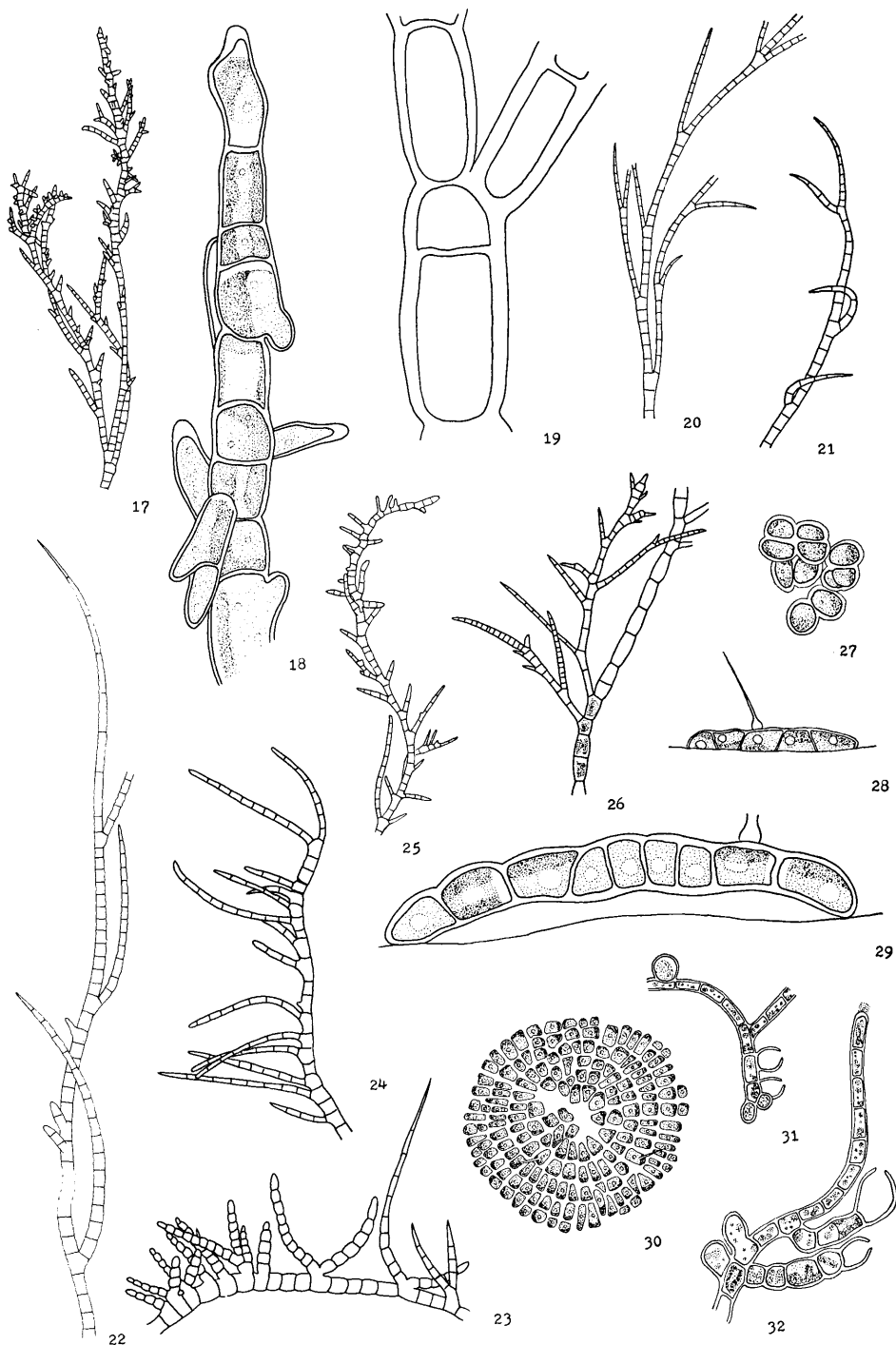
Probably generally distributed in island region from late spring through summer to autumn. Attached to rock or, at maturity, becoming free-floating.

Cladophora glomerata (L.) Kuetzing (fig. 34)

Prescott (1962), p. 138.

EXPLANATION OF FIGURES 17-32

FIGS. 17-32. FIGS. 17, 18, 19. *Stigeoclonium pachydermum* Prescott var. *pachydermum*: 17, habit; 18, detail of irregular branching; 19, detail of wall thickness. FIGS. 20, 21. *Stigeoclonium stagnatile* (Hazen) Collins: 20, habit; 21, curved secondary branches. FIGS. 22, 23, 24, 25. *Stigeoclonium subsecundum* (Kuetzing) Kuetzing var. *subsecundum*: 22 and 25, habit; 23 and 24, detail of unilateral branching. FIG. 26. *Stigeoclonium tenue* (C. A. Agardh) Kuetzing var. *tenue*. FIG. 27. *Protococcus viridis* C. A. Agardh. FIG. 28. *Aphanochaete repens* A. Braun. FIG. 29. *Aphanochaete vermiculoides* Wolle. FIG. 30. *Coleochaete orbicularis* Pringsheim. FIGS. 31, 32. *Trentepohlia aurea* (L.) Martius: 31, filament with lateral sporangia; 32, filament with terminal sporangia and pectose cap.



Thallus filamentous, repeatedly and regularly branched, the branches usually crowded toward the tip of the plant. Chloroplast reticulate parietal with many pyrenoids. Cells cylindrical; cell walls thick and lamellate. Cells of main axis 63 to 90 μ in diameter, their length two to four times the diameter; branch cells 38 to 45 μ in diameter, their length two to four times the diameter.

Along most shorelines in island region, attached to rock, concrete, and metal pipe.

Rhizoclonium hieroglyphicum (C. A. Agardh) Kuetzing (fig. 35)

Prescott (1962), p. 142.

Filamentous with infrequent short papilla-like branches. Filaments cylindrical, cell walls thick. Chloroplast parietal reticulate with many pyrenoids. Cells 18 to 25 μ in diameter, 26.6 to 43.5 μ long.

Green Island and South Bass Island with other algae. Probably of general distribution. Attached to rock or metal pipe that is washed or splashed by wave action.

Arnoldiella conchophila Miller (figs. 36, 37, 38)

Fritsch (1935), p. 245, and Miller (1928), p. 1-21.

Filaments heterotrichous, consisting of a basal, one-cell-thick prostrate system, from which short, closely packed, dichotomously branched, upright filaments arise. Cells cylindrical, 12 to 24 μ in diameter, 12 to 39 μ long, the basal cells being essentially quadrate. Cell walls up to 2.4 μ thick and lamellated. Chloroplast reticulate parietal. Terminal sporangia with an apical pore.

Green Island at northeast cove and South Bass Island at laboratory director's house and again on the west shore, on *Cladophora*, wood, metal pipe, and dolomite rock.

Arnoldiella is a rare alga, this being a new record for the United States. It was previously found on mussel shells in a central Russia lake. It is apparently well established in Lake Erie, being found in three localities on six different occasions. The compact upright filaments and reticulate parietal plastids distinguish it from *Gongrosira*.

CYANOPHYTA

MYXOPHYCEAE

Chroococcales

Chlorogloea microcystoides Geitler (fig. 39, 40)

Geitler (1925), p. 122.

Thallus a gelatinous, lobed, brownish crust. Cells spherical or appressed flattened, with or without a thin unlamellated sheath; in a common colorless to golden-brown mucilage; arranged in straight rows which may or may not be apparent. Cells 2.5 to 3 μ in diameter.

Generally distributed in island region, on dolomite rock washed or splashed by waves, under a layer of filamentous blue-green algae.

Chamaesiphonales

Chamaesiphon incrustans Grunow (fig. 41)

Prescott (1962), p. 477.

Cells straight, club-shaped, and gregarious. Surrounded by an open colorless sheath from the narrow attaching basal portion to the widened apex where endospores are successively cut off. Cell apex 3.6 μ in diameter, cells 10 to 17 μ long.

Generally distributed in island region from early spring through summer, growing as an epiphyte on *Cladophora*.

Hormogonales

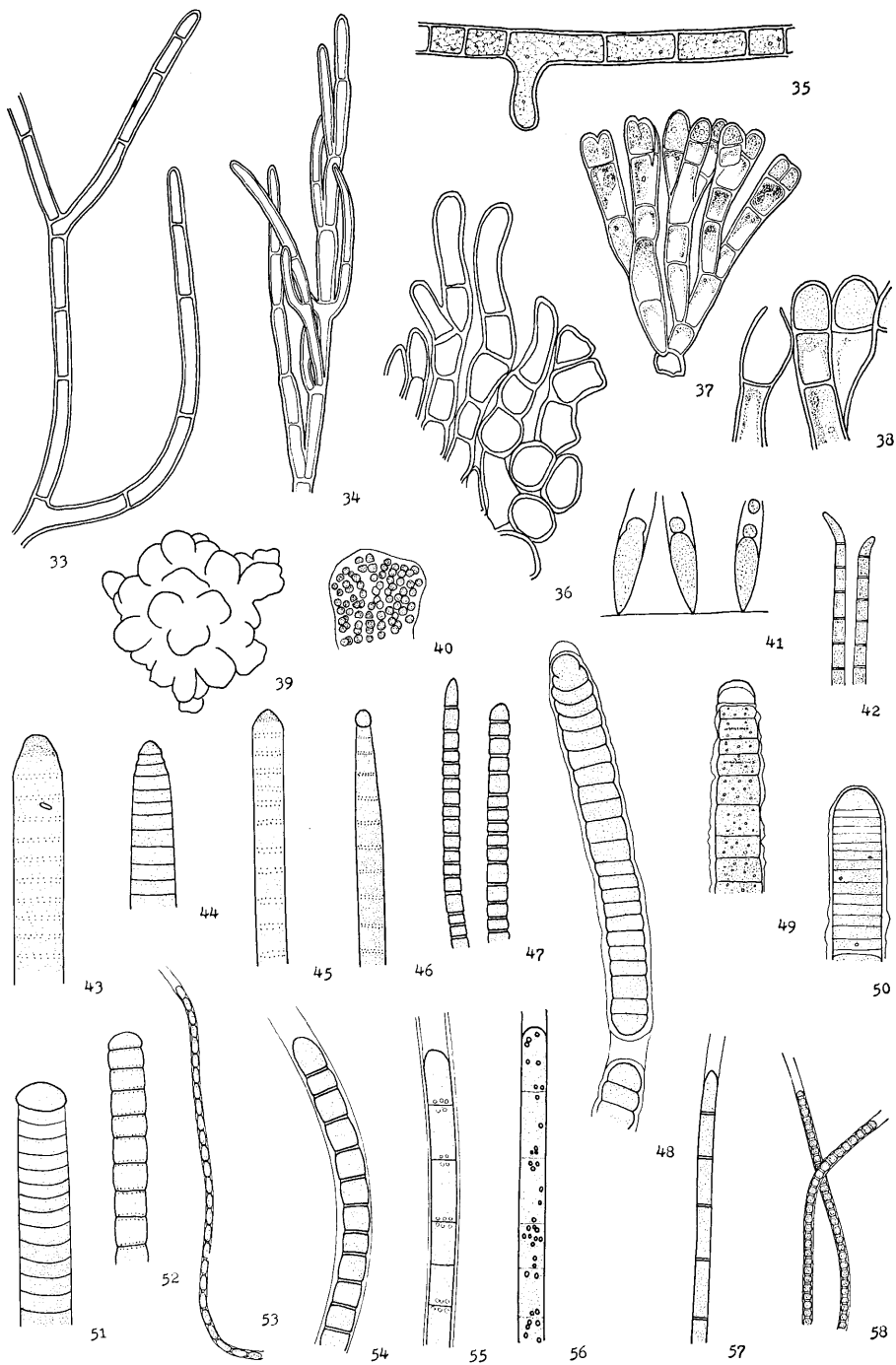
Oscillatoria acutissima Kufferath (fig. 42)

Prescott (1962), p. 484.

Trichomes solitary and scattered among other algae or forming a loosely interwoven thallus. Filamentous but without an evident sheath; not constricted at the cross walls, which

EXPLANATION OF FIGURES 33-58

FIGS. 33-58. FIG. 33. *Cladophora fracta* (Dillw.) Kuetzing. FIG. 34. *Cladophora glomerata* (L.) Kuetzing. FIG. 35. *Rhizoclonium hieroglyphicum* (C. A. Agardh) Kuetzing. FIGS. 36, 37, 38. *Arnoldiella conchophila* Miller: 36, prostrate system; 37, upright filaments; 38, sporangium. FIGS. 39, 40. *Chlorogloea microcystoides* Geitler: 39, habit; 40, cell arrangement. FIG. 41. *Chamaesiphon incrustans* Grunow. FIG. 42. *Oscillatoria acutissima* Kufferath. FIGS. 43, 44. *Oscillatoria agardhii* Gomont. FIGS. 45, 46. *Oscillatoria amoena* (Kuetzing) Gomont. FIG. 47. *Oscillatoria boryana* Bory. FIGS. 48, 49, 50. *Oscillatoria sancta* (Kuetzing) Gomont. FIG. 51. *Oscillatoria limosa* (Roth) C. A. Agardh. FIG. 52. *Oscillatoria tenuis* C. A. Agardh. FIG. 53. *Phormidium angustissimum* W. & G. S. West. FIG. 54. *Phormidium molle* (Kuetzing) Gomont. FIGS. 55, 56. *Phormidium inundatum* Kuetzing. FIG. 57. *Phormidium laminosum* (C. A. Agardh) Gomont. FIG. 58. *Phormidium foveolarum* (Mont.) Gomont.



are not granular; apex slightly tapered and bent. Trichomes $1.5\ \mu$ in diameter, cells 2.5 to $3\ \mu$ long.

Green Island and Starve Island, on sides of rock pools.

Oscillatoria agardhii Gomont (figs. 43, 44)

Prescott (1962), p. 484.

Trichomes scattered among other algae or forming a loose plant mass. Filamentous but without an evident sheath; not constricted at the cross walls, which may be granular; apex abruptly tapering; apical cell with a calyptra and often capitate. Trichome $6\ \mu$ in diameter, cells 2.4 to $4.8\ \mu$ long.

South Bass Island and Starve Island, on surfaces washed or splashed by waves.

Oscillatoria amoena (Kuetzing) Gomont (figs. 45, 46)

Prescott (1962), p. 484.

Trichomes scattered among other algae or forming a loose plant mass. Filamentous but without an evident sheath; not constricted at the cross walls, which are usually granular. Apex slightly tapering, capitate, or with a cone-shaped calyptra. Trichomes $4.8\ \mu$ in diameter, cells 2.4 to $4.8\ \mu$ long.

Generally distributed in island region, on exposed substrates.

Except for the small difference in trichome diameter, this species is much like *O. agardhii*. Desikachary (1959) describes a variety *O. amoena* var. *non-granulata* Ghose which lacks the granules at the cross walls. A large number of the collections show this variation in some of the trichomes. This, as well as the size difference, led me to believe this to be *O. amoena*.

Oscillatoria boryana Bory (fig. 47)

Desikachary (1959), p. 218.

Trichomes scattered among other algae. Filamentous but without an evident sheath; straight throughout entire length. Constricted at the cross walls, which are not granular. Apex rounded or conically pointed. Trichomes 5.5 to $6\ \mu$ in diameter, cells 3.6 to $4.8\ \mu$ long.

Catawba Point, South Bass Island, and Sugar Island, on submersed wood and rock. Probably generally distributed in island region.

It may be that my specimens are *Schizothrix friesii* Gomont, which has trichomes of much the same general appearance. Identification as *Oscillatoria boryana* was based on the presence of so many trichomes without a sheath of any kind.

Oscillatoria limosa (Roth) C. A. Agardh (fig. 51)

Prescott (1962), p. 489.

Trichomes scattered among other algae. Filamentous but without an evident sheath; straight throughout entire length; not constricted at the cross walls, which are not granular. Apical cell with thickened tip. Trichome $12\ \mu$ in diameter, cells $4.8\ \mu$ long.

Generally distributed in island region, on submersed substrates.

Oscillatoria sancta (Kuetzing) Gomont (figs. 48, 49, 50)

Prescott (1962), p. 490.

Trichomes loosely aggregated or scattered among other algae. Filamentous, but without a sheath which extends beyond the apex of the trichome; straight throughout entire length, or slightly tapering at the apex; constricted at cross walls, which are not granular. Cell contents sometimes coarsely granular. Apical cell commonly capitate and with a calyptra. Trichome 8.5 to 9.7 (12) μ in diameter, cells 2.4 to $6\ \mu$ long.

South Bass Island, in a small shoreline pool near airport, with *Hydrodictyon reticulatum* (L.) Lagerheim. Collected by Richard Pecora.

Though not strictly a shoreline species, a description is included here because this collection represents a new record of this species for the island region.

Oscillatoria tenuis C. A. Agardh (fig. 52)

Prescott (1962), p. 491.

Trichomes scattered among other algae. Filamentous but without an evident sheath; straight throughout entire length; constricted at cross walls, which are granular. Apical cell broadly rounded. Trichome $7.3\ \mu$ in diameter, cells $3.6\ \mu$ long.

Generally distributed in island region, on washed and wave-splashed rock surfaces.

Phormidium angustissimum W. & G. S. West (fig. 53)

Desikachary (1959), p. 253.

Thallus of entangled filaments, thin and leathery. Filament of an unbranched, uniseriate, cylindrical trichome enclosed in a thin colorless sheath. Trichomes constricted at cross walls, which are not granular; apical cell rounded. Trichomes 0.8 to $1\ \mu$ in diameter, cells 2 to $3\ \mu$ long.

Generally distributed in island region, forming a plant mass on submersed, washed, or splashed substrates.

Phormidium foveolarum (Mont.) Gomont (fig. 58)

Desikachary (1959), p. 254.

Thallus of entangled filaments, each filament of an unbranched, uniseriate, cylindrical trichome enclosed in a thin colorless sheath. Trichome constricted at the cross walls, which are not granular; apical cell rounded. Filament $2.1\ \mu$ wide; trichome $1.5\ \mu$ in diameter; cells 1.3 to $1.7\ \mu$ long.

Generally distributed in island region, on submersed and washed substrates.

Phormidium inundatum Kuetzing (figs. 55, 56)

Prescott (1962), p. 494.

Thallus a gelatinous, membranous expanse of filaments. Filament of an unbranched, uniseriate, cylindrical trichome enclosed in a relatively thin, colorless sheath. Cell walls not constricted, occasionally granular; cytoplasmic contents commonly coarsely granular; apical cell rounded to rounded-conical. Filament $4.8\ \mu$ wide; trichome $4.5\ \mu$ in diameter; cells 4.8 to $6\ \mu$ long.

Generally distributed in island region, from early spring through summer, on submersed, washed, or splashed substrates.

Phormidium laminosum (C. A. Agardh) Gomont (fig. 57)

Tilden (1910), p. 96.

Thallus of entangled filaments, tough and cushion-shaped. Filament of an unbranched, uniseriate, cylindrical trichome enclosed in a thin colorless sheath; cell walls not constricted, occasionally appearing granular; apical cell short conical. Trichome 1 to $1.5\ \mu$ in diameter; cells 3.5 to $4\ \mu$ long.

Generally distributed in island region, on submersed, washed, or splashed substrates.

Phormidium molle (Kuetzing) Gomont (fig. 54)

Desikachary (1959), p. 255.

Thallus membranous, of entangled filaments. Filament of an unbranched, uniseriate, cylindrical trichome enclosed in a thin colorless sheath. Cell walls constricted and not granular; apical cell rounded. Filament $3.8\ \mu$ wide; trichome 3 to $3.4\ \mu$ in diameter; cells 3 to $4.8\ \mu$ long.

Green Island and South Bass Island, in temporary pools or on rock splashed by waves.

Lyngbya aerugineo-caerulea (Kuetzing) Gomont (figs. 60, 61)

Prescott (1962), p. 498.

Thallus of entangled filaments or solitary filaments scattered among other plants. Filaments of an unbranched, uniseriate, cylindrical trichome enclosed in a relatively firm, colorless sheath. Trichomes not constricted at the cross walls, which are commonly granular; apical cell rounded-conical or capitate. Filaments 7 to $12\ \mu$ wide; trichomes 4.8 to $7.3\ \mu$ in diameter; cells $2.4\ \mu$ long.

Generally distributed in island region, on submersed or wave-splashed dolomite or wood.

Lyngbya aestuarii (Mert.) Liebmam (fig. 59)

Prescott (1962), p. 499.

Thallus of entangled filaments. Filaments of an unbranched, uniseriate, cylindrical trichome enclosed in a relatively firm, colorless sheath. Cell contents homogeneous; cross walls occasionally indistinct, not constricted; apical cell rounded. Filaments 10 to $15\ \mu$ wide; trichome 8 to $11\ \mu$ in diameter; cells 2.4 to $4.8\ \mu$ long.

Sugar Island, on submersed wood of boat dock.

Lyngbya allorgei Pr  my (fig. 64)

Desikachary (1959), p. 313.

Filaments of an unbranched, uniseriate, cylindrical trichome enclosed in a rather thin colorless sheath. Trichome not constricted at cross walls, which are occasionally granular; apical cell rounded. Filament 3.5 to $4.8\ \mu$ wide; trichome $3\ \mu$ in diameter; cells 3 to $4.8\ \mu$ long.

Probably generally distributed in island region, on rock washed or splashed by waves.

This differs from Desikachary's description in that the cross walls are occasionally granular.

Lyngbya diguetii Gomont (figs. 68, 69, 70, 71)

Prescott (1962), p. 500.

Plants solitary or entangled to form layers or bundles; commonly epiphytic on larger algae. Filaments of an unbranched, uniseriate, cylindrical trichome enclosed in a relatively firm sheath. Sometimes rapid growth causes contortion and breaking of trichome within sheath, giving appearance of more than one trichome in a sheath. Trichome not constricted at cross walls (sometimes thick cross walls give the appearance of constrictions), which are not granular; apical cell rounded. Filament 3 to $3.5\ \mu$ wide; trichome 2 to $2.4\ \mu$ in diameter; cells 1.5 to $2\ \mu$ long.

Generally distributed in island region, on wood or rock, and on *Cladophora*.

The trichome diameter is somewhat smaller than that given by Prescott.

Lyngbya epiphytica Hieronymus (fig. 67)

Prescott (1962), p. 500.

Plants epiphytic on larger filamentous algae to which they adhere for their entire length. Filaments of an unbranched, uniseriate, cylindrical trichome within a thin colorless sheath. Not constricted at the cross walls, which are not granular. Apical cell rounded. Filament $1.2\ \mu$ wide; trichome $1.7\ \mu$ in diameter; cells $1\ \mu$ long.

Catawba Point, early spring, adhering to old *Cladophora*.

Lyngbya kuetzingii Schmidle (fig. 62)

Desikachary (1959), p. 282.

Plants epiphytic, growing attached to larger filamentous algae. Filaments of an unbranched, uniseriate, cylindrical trichome within a thin colorless sheath. Trichome not

constricted at cross walls, which are not granular; apical cell rounded. Filament $2\ \mu$ wide; trichome $1.5\ \mu$ in diameter; cells 1 to $1.5\ \mu$ long.

Generally distributed in island region, as an epiphyte on *Cladophora*.

The only basis for not calling this *L. diguetii* is its smaller diameter. In all other respects its appearance is the same.

Lyngbya taylorii Drouet and Strickland (fig. 63)

Prescott (1962), p. 503.

Filaments scattered among other algae; composed of an unbranched, uniseriate, cylindrical trichome within a thin, colorless sheath. Trichome not constricted at cross walls; apical cell rounded; cytoplasmic contents granular. Filaments 7 to $7.3\ \mu$ wide; trichome $6\ \mu$ in diameter; cells 3.6 to $6\ \mu$ long.

Catawba Point, Middle Bass Island, and Sugar Island, on submersed wood or rock. Probably generally distributed.

Lyngbya versicolor (Wartmann) Gomont (figs. 65, 66)

Prescott (1962), p. 504.

Plant forming a mass of much-entangled filaments. Filament an unbranched, uniseriate, cylindrical trichome within a thick colorless sheath. Trichomes not constricted at the cross walls, which are not granular and are usually indistinct; apical cell rounded. Filaments $4\ \mu$ wide; trichomes $3\ \mu$ in diameter.

Generally distributed in island region, on wood and rock washed and splashed by waves.

Hydrocoleum homoeotrichum Kuetzing (figs. 76, 77)

Tilden (1910), p. 137.

Filaments unbranched; sheath thin or thick and lamellate. Trichomes one to several within the sheath, not constricted at the cross walls. Cross walls indistinct, but granular; apex tapering little and capitate. Cells $7.3\ \mu$ in diameter, $4.8\ \mu$ long.

Generally distributed in island region, attached to dolomite, concrete, or wood washed or splashed by waves.

Microcoleus delicatulus W. & G. S. West (fig. 72)

Pasher (1925), p. 435.

Thallus of many parallel trichomes enclosed by a wide, gelatinous sheath. Trichomes unbranched, cylindrical, not constricted at cross walls, which are granular. Apical cell rounded. Trichomes 1.6 to $2.4\ \mu$ in diameter; cells 2 to $2.6\ \mu$ long.

Catawba Point, early spring, on dolomite of temporary pool.

Microcoleus minimus Frémy (fig. 73)

Geitler (1932), p. 1140.

Thallus of many parallel trichomes enclosed by a close gelatinous sheath. Trichomes unbranched, cylindrical, constricted at the cross walls, which are not granular. Apical cell rounded-conical. Trichome $2\ \mu$ in diameter; cells 1.5 to $3\ \mu$ long.

Starve Island, on dolomite of pool.

Microcoleus vaginatus (Vauch.) Gomont (figs. 74, 75)

Prescott (1962), p. 506.

Thallus of many parallel trichomes enclosed by a wide, colorless, gelatinous sheath, which may be wrinkled. Trichomes unbranched, not constricted at the cross walls, which are not granular. Apex slightly tapered, apical cell capitate. Trichomes $4.8\ \mu$ in diameter; cells $6.7\ \mu$ long.

North Bass Island and Starve Island, probably generally distributed on submersed, washed, and splashed wood and rock.

Schizothrix calcicola (C. A. Agardh) Gomont (figs. 82, 83, 84)

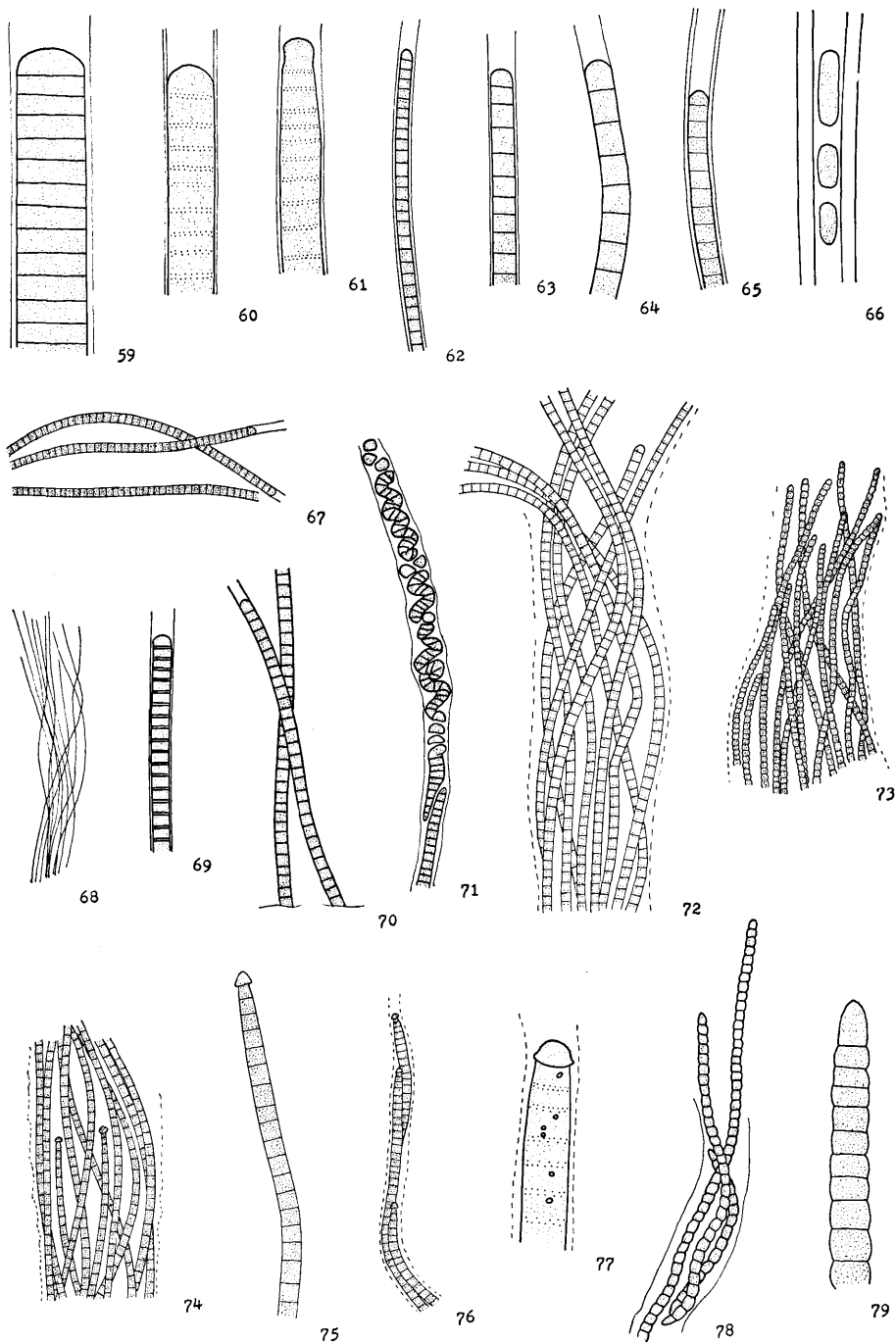
Drouet (1963), p. 261-281.

Thallus calcified or not; filaments relatively short and growing as cushions in a perpendicular (to the substrate) parallel fashion. Sheath thin, colorless, extending some distance beyond trichome. Trichome the same diameter throughout, except in the common instances where it tapers gradually or abruptly into a "hair" as long or longer than the trichome. Constricted at cross walls, which are not granular. Terminal cell rounded-conical. Filaments $6\ \mu$ wide; trichome $4.8\ \mu$ in diameter; cells 2.4 to $4.8\ \mu$ long.

Green Island, South Bass Island, and Starve Island, on submerged dolomite, *Cladophora*, or prostrate portions of *Stigeoclonium*.

EXPLANATION OF FIGURES 59-79

FIGS. 59-79. FIG. 59. *Lyngbya aesturarii* (Mert.) Liebmann. FIGS. 60, 61. *Lyngbya aerugineo-caerulea* (Kuetzing) Gomont. FIG. 62. *Lyngbya kuetzingii* Schmidle. FIG. 63. *Lyngbya taylorii* Drouet & Strickland. FIG. 64. *Lyngbya allorgei* Frémy. FIGS. 65, 66. *Lyngbya versicolor* (Wartmann) Gomont. FIG. 67. *Lyngbya epiphytica* Hieronymus. FIGS. 68, 69, 70, 71. *Lyngbya diguetii* Gomont: 68, habit; 69-71, variations in filament morphology. FIG. 72. *Microcoleus delicatulus* W. & G. S. West. FIG. 73. *Microcoleus minimus* Frémy. FIGS. 74, 75. *Microcoleus vaginatus* (Vauch.) Gomont: 74, habit; 75, trichome detail. FIGS. 76, 77. *Hydrocoleum homoeotrichum* Kuetzing: 76, habit; 77, trichome detail. FIGS. 78, 79. *Schizothrix friesii* Gomont: 78, habit; 79, trichome detail.



Dr. Frances Drouet examined a slide of the material and made the identification. The generic character of more than one trichome within a sheath was lacking. The "ephemeral hairs" noted by Bornet and Flahault (Drouet, 1963) at the upper ends of the trichomes were present but not observed by Drouet.

Schizothrix fasciculata (Naeg.) Gomont (fig. 85)

Prescott (1962), p. 507.

Plant mass thickly encrusted with calcium carbonate, forming an expanded, cushion-shaped thallus. Several trichomes present within a mucilage sheath, the sheath expanded above and involving many trichomes, but narrowing toward the base to a point. Trichomes cylindrical, constricted at cross walls; end cells conical-pointed. Trichomes 1 to 1.5 μ in diameter; cells 1 to 2 μ long.

Middle Bass Island, north shore, on dolomite washed by waves.

Schizothrix friesii Gomont (figs. 78, 79)

Prescott (1962), p. 507.

Thalli scattered among other algae; consisting of single or several trichomes within a branched mucilage sheath. Trichomes cylindrical, constricted at cross walls; end cell conical. Trichomes 4.8 μ in diameter; cells quadrate.

South Bass Island and Sugar Island, on submersed wood of boat dock.

Schizothrix lacustris A. Braun (figs. 80, 81)

Prescott (1962), p. 507.

Thalli scattered among other algae, consisting of several trichomes within a wide mucilage sheath. Trichomes cylindrical, constricted at cross walls; end cell conical-pointed. Trichomes (1.5) 2 (3) μ in diameter; cells 4 to 6 μ long.

Catawba Point and South Bass Island in early spring and fall, on submersed dolomite.

Schizothrix lardacea (Cesati) Gomont (fig. 86)

Prescott (1962), p. 508.

Thallus a firm layer. Trichomes several within a wide mucilage sheath, cylindrical, not constricted at cross walls. Cytoplasmic contents granular, but not restricted to the cross walls. Apical cell rounded. Trichomes 1.2 to 2 μ in diameter; cells quadrate to 3 μ long.

Green Island, North Bass Island, and South Bass Island, on dolomite in pools or where splashed by waves. Probably generally distributed.

Schizothrix lateritia (Kuetzing) Gomont (fig. 87)

Desikachary (1959) p. 326.

Thin, leathery thallus consisting of many entangled filaments. Several trichomes united within a large mucilage sheath, the individual trichomes each in another, smaller sheath within the larger sheath. Trichomes cylindrical, not constricted at the cross walls; apical cell rounded. Trichomes 1 to 1.5 μ in diameter; cells 4 to 5 μ long.

Green Island, North Bass Island, and South Bass Island, on dolomite washed or splashed by waves. Probably of general distribution.

Schizothrix pulvinata (Kuetzing) Gomont (fig. 88)

Desikachary (1959), p. 323.

Trichomes several, surrounded by a mucilage sheath. Trichomes cylindrical, constricted at the cross walls, apical cell rounded. Trichomes 1 to 1.5 μ in diameter; cells 1.3 to 1.7 μ long.

Generally distributed in island region, on surfaces washed or splashed by waves.

Nostoc caeruleum Lyngbye (figs. 89, 90)

Tilden (1910), p. 177.

Colonies very small, spherical, solid, becoming yellow with age. Trichomes densely interwoven and twisted, cells barrel-shaped. Heterocysts intercalary, barrel-shaped, 5.2 μ in diameter, 6.4 μ long. Trichomes 3.6 μ in diameter; cells 3.6 to 4.8 μ long.

Generally distributed in island region, on dolomite or wood.

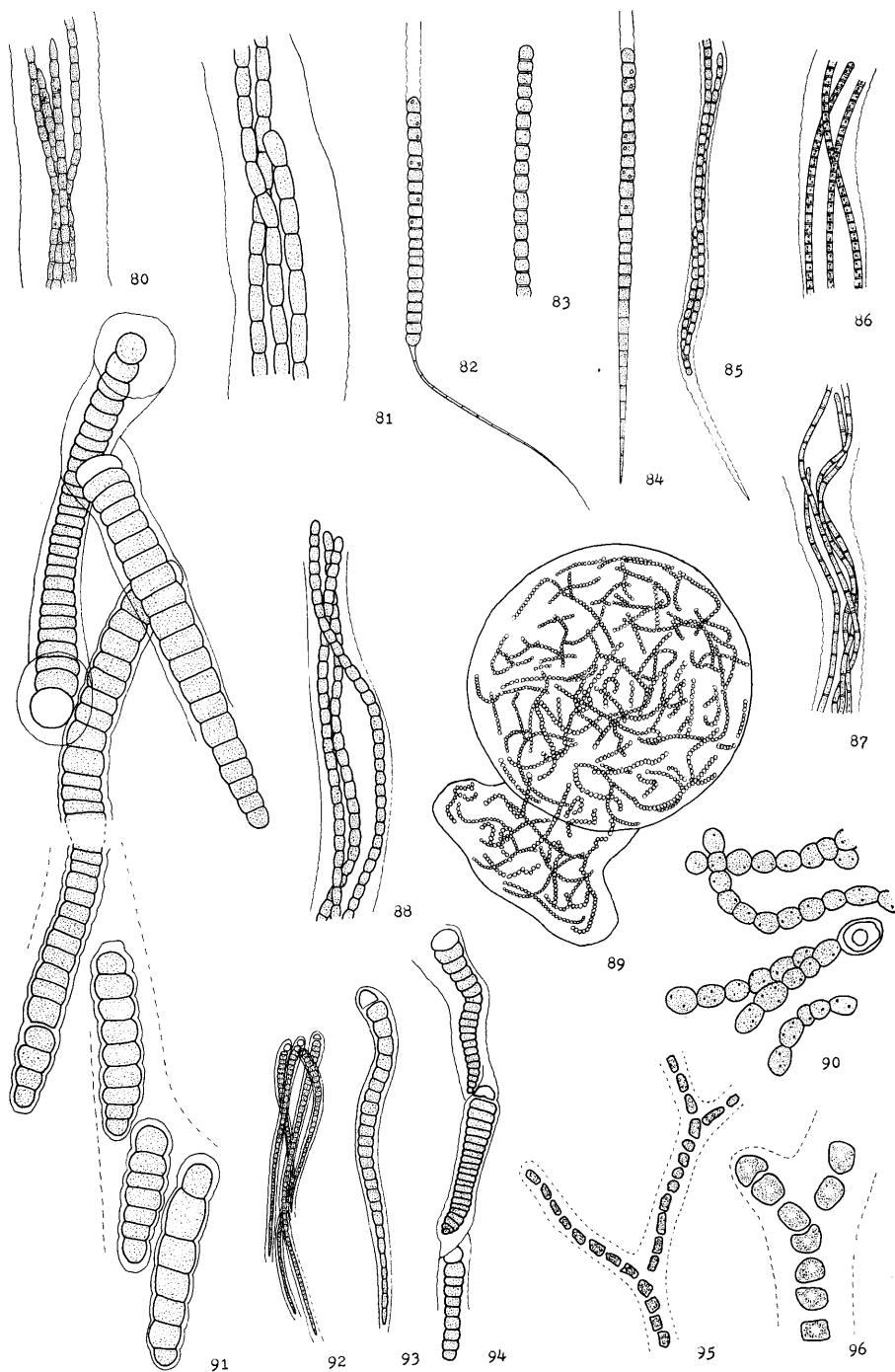
Tolypothrix byssoidea (Berk.) Kirchner (fig. 91)

Desikachary (1959), p. 502.

Filaments scattered among other algae; consisting of a falsely branched trichome surrounded by a thick sheath becoming brown with age. Filament tapering somewhat from base,

EXPLANATION OF FIGURES 80-96

FIGS. 80-96. FIGS. 80, 81. *Schizothrix lacustris* A. Braun. FIGS. 82, 83, 84. *Schizothrix callicola* (C. A. Agardh) Gomont: 82 and 84, trichome with "tail"; 83, trichome without "tail". FIG. 85. *Schizothrix fasciculata* (Naeg.) Gomont. FIG. 86. *Schizothrix lardacea* (Cesati) Gomont. FIG. 87. *Schizothrix lateritia* (Kuetzing) Gomont. FIG. 88. *Schizothrix pulvinata* (Kuetzing) Gomont. FIGS. 89, 90. *Nostoc caeruleum* Lyngbye: 89, habit; 90, cell detail and heterocyst. FIG. 91. *Tolypothrix byssoidea* (Berk.) Kirchner. FIG. 92, 93. *Calothrix braunii* (A. Braun) Bornet & Flahault: 92, habit; 93, trichome detail. FIG. 94. *Calothrix parietana* (Naeg.) Thuret. FIGS. 95, 96. *Asterocylis smaragdina* (Reinsch) Forti: 95, habit of branching; 96, cell detail.



constricted at cell walls. Hormogonia formed from apex. Heterocysts basal, spherical, about $6.3\ \mu$ in diameter. Filament $12\ \mu$ wide; basal cells $7.3\ \mu$ wide by $2\ \mu$ long; apical cells $4.4\ \mu$ wide by $3.2\ \mu$ long.

Catawba Point, in early spring, on dolomite in temporary pool.

Calothrix braunii (A. Braun) Bornet & Flahault (figs. 92, 93)

Desikachary (1959), p. 535.

Thallus composed of straight, parallel filaments. Sheath thin and colorless. Trichomes constricted at cross walls, tapering from the base and becoming hair-like. Heterocyst basal, hemispherical, $4.8\ \mu$ in diameter. Filament $9.7\ \mu$ in diameter; basal cells $6\ \mu$ in diameter, 2.4 to $3\ \mu$ long.

Gibraltar Island and South Bass Island, on submersed, washed, or splashed dolomite.

Probably generally distributed.

Calothrix parietana (Naeg.) Thuret (fig. 94)

Prescott (1962), p. 553.

Filaments solitary or gregarious, often branched. Sheath thick, unlamellated, golden-brown when old. Trichomes constricted at cross walls, tapering from base, but not to a hair. Heterocyst basal, hemispherical, $4.8\ \mu$ in diameter. Filament 8.5 to $12\ \mu$ in diameter; basal cells $7.3\ \mu$ in diameter, 1.5 to $3.6\ \mu$ long.

Generally distributed in island region, on dolomite washed and splashed by waves.

RHODOPHYTA

RHODOPHYCEAE

Bangiales

Asterocytis smaragdina (Reinsch) Forti (figs. 95, 96)

Prescott (1962), p. 563.

Filaments branched, composed of uniseriate quadrate, or elongate cells within a broad, gelatinous sheath. Branches developed by slipping of cells to one side and division of these cells in another plane. Chloroplast axial, stellate, with a central pyrenoid. Cells $7.3\ \mu$ in diameter, 7.3 to $12\ \mu$ long.

Generally distributed in island region, attached to dolomite or *Cladophora*.

Plants attached to rock are much longer and more infrequently branched than the epiphytes.

TAXA REPRESENTING NEW RECORDS IN WESTERN LAKE ERIE

CHLOROPHYTA

CHLOROPHYCEAE

Ulotricales

Ulothrix varabilis Kuetzing

Chaetophorales

Stigeoclonium amoenum Kuetzing

Stigeoclonium carolinianum Islam

Stigeoclonium elongatum (Hassall) Kuetzing

Stigeoclonium pachydermum Prescott var. *pachydermum*

Aphanochaete vermiculoides Wolle

Cladophorales

Arnoldiella conchophila Miller

CYANOPHYTA

MYXOPHYCEAE

Chroococcales

Chlorogloea microcystoides Geitler

Chamaesiphonales

Chamaesiphon incrustans Grunow

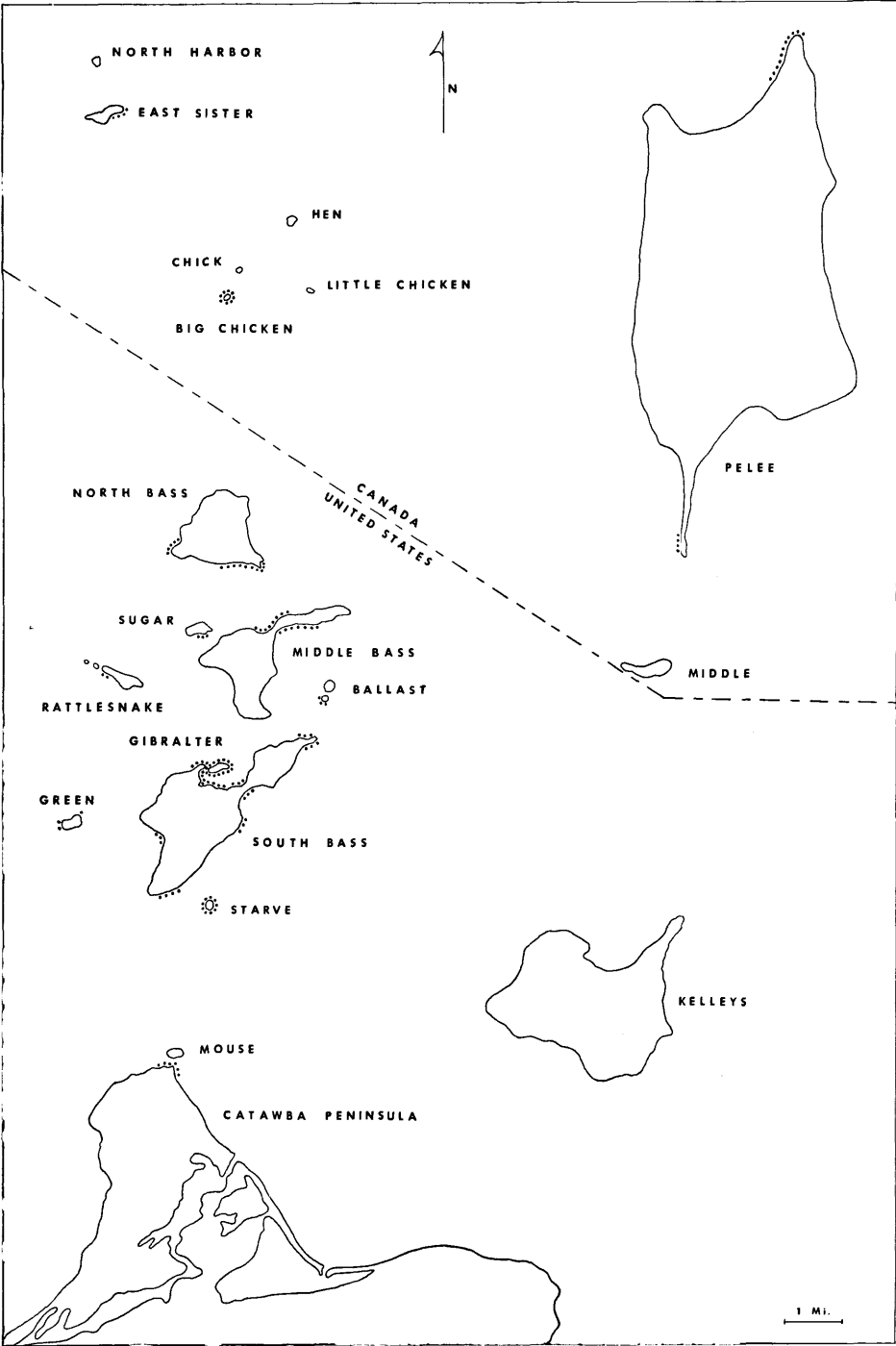


FIGURE 97. Map of the island region of Western Lake Erie. Collection areas are indicated by dots.

Hormogonales

Oscillatoria acutissima Kufferath
Oscillatoria amoena (Kuetzing) Gomont
Oscillatoria boryana Bory
Oscillatoria sancta (Kuetzing) Gomont
Phormidium angustissimum W. & G. S. West
Phormidium foveolarum (Mont.) Gomont
Phormidium inundatum Kuetzing
Phormidium laminosum (C. A. Agardh) Gomont
Phormidium molle (Kuetzing) Gomont
Lyngbya aerugineo-caerulea (Kuetzing) Gomont
Lyngbya allorgei Frémy
Lyngbya diguetii Gomont
Lyngbya epiphytica Hieronymus
Lyngbya kuetzingii Schmidle
Lyngbya taylorii Drouet & Strickland
Lyngbya versicolor (Wartmann) Gomont
Hydrocoleum homoeotrichum Kuetzing
Microcoleus delicatulus W. & G. S. West
Microcoleus minimus Frémy
Microcoleus vaginatus (Vauch.) Gomont
Schizothrix calcicola (C. A. Agardh) Gomont
Schizothrix fasciculata (Naeg.) Gomont
Schizothrix friesii Gomont
Schizothrix lacustris A. Braun
Schizothrix lateritia (Kuetzing) Gomont
Schizothrix pulvinata (Kuetzing) Gomont
Tolypothrix byssoidea (Berk) Gomont
Calothrix braunii (A. Braun) Bornet & Flahault
Calothrix parietana (Naeg.) Thuret

Algae are found almost everywhere along the shorelines of western Lake Erie. There is, however, no one shoreline habitat where one can be assured of finding a large number of different kinds of algae. The collecting site near the director's house did not result in any species not found elsewhere. Algae are not found under the combined conditions of very strong wave action and unstable shore. Strong wave action alone did not limit the growth of algae.

Substrates and water depth are sometimes important factors in determining where a species or class of algae will grow. *Uronema elongatum*, *Aphanochaete repens*, *A. vermiculoides*, *Chamaesiphon incrustans* and *Lyngbya epiphytica* were always epiphytes on *Cladophora glomerata*. *Coleochaete orbicularis* was found as an epiphyte on the flowering aquatic, *Vallisneria americana* Michx. Others, such as *Tetraspora gelatinosa*, *Arnoldiella conchophila*, *Lyngbya diguetii*, *L. kuetzingii* and *Asterocylis smaragdina*, are sometimes epiphytes on *Cladophora glomerata*. The Myxophyceae more frequently occupy substrates washed or splashed by wave action. Often this substrate is dolomite, but concrete, wood, or metal is also commonly found covered by mats of blue-green algae.

Little variation in numbers or species of algae occurs until late May or June. The greatest number of individuals and of taxa occurs in July and August. Species present only in early spring were: *Ulothrix variabilis*, *Tolypothrix byssoidea*, *Schizothrix lacustris*, *Microcoleus delicatulus*, and *Lyngbya epiphytica*. Of these, *Ulothrix variabilis* was the only one found in enough abundance to be considered an early spring component of the shoreline flora. *Ulothrix tenerima* occurs most abundantly in early spring and late fall and may be considered a cold-water alga.

In spite of some 70 years of algal studies in the western Lake Erie region, 39 of the total of 61 taxa identified are new records for the area; these previously unreported taxa are listed above. This clearly indicates that anyone doing a taxonomic or ecological study of a similar area should study the shorelines as extensively as the open water or ponds.

This study is in no way considered to be complete. One of the interesting aspects of algal ecology is the variation found from year to year in numbers of

individuals and kinds of species. Collections for this study were made during the summer of 1967 when the water levels of Lake Erie had been low and the shoreline had been exposed for several years, allowing establishment of the algae reported in this study. The same type of study, if conducted during the summer of 1968, when the level of the lake was a foot above that of the summer of 1967 and two feet above that of the summer of 1966, would probably have yielded fewer, and maybe different species. Extensive, long-term collecting will be necessary in order to give a complete picture of the composition of the shoreline algae of Lake Erie and will be demanded before the abundance of these taxa can adequately be judged.

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